10.0 IDENTIFICATION AND INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS

This section presents technologies and process options that may be implemented to meet the general response actions identified in Section 9.0. Technologies and process options are evaluated and initially screened to eliminate infeasible or ineffective technologies from further consideration. This preliminary screening is qualitative, not quantitative, based on engineering experience. The initial screening of remedial technologies and process options is summarized in Table 10-1.

Remedial technologies are defined as general categories or types of remedies for response actions. Remedial process options are specific methods to implement a technology. The following sections discuss process options for each technology.

10.1 MONITORING

A groundwater monitoring program is implemented for the No Action response action to track contaminant plume movement. Monitoring data can be used as a valuable source of information if further action is required in the future.

Initial Screening - This technology is retained for further evaluation as required by the NCP.

10.2 GROUNDWATER USE RESTRICTIONS

To protect public health from ingestion of contaminated groundwater, the use of this water must be restricted when contaminants exceed acceptable drinking water levels. An existing wellfield may have specific wells decommissioned or new wells may be installed in appropriate uncontaminated areas, or some other alternate water supply must be designated.

Table 10-1

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER

General Response Action	Technology	Process Option	Preliminary Screening Comments
No Action	Monitoring	Monitoring	Required by NCP
Institutional Actions	Groundwater use restrictions	Alternate Water Supply	Potentially feasible
Collection/Treatment/Disposal			
Collection	Extraction	Extraction Wells	Potentially feasible
		Municipal Production Wells	Potentially feasible
	Subsurface Drains	French Drain	Not feasible due to large plume area and aquifer depth
Treatment	Biological (On-Site)	Aerobic Oxidation	Not feasible, undemonstrated for chlorinated organic compounds
		Anaerobic Digestion	Not feasible, undemonstrated for chlorinated organic compounds
	Physical/Chemical (On-Site)	Aqueous Granular Activated Carbon (GAC)	Potentially feasible
		Air Stripping with Vapor Phase GAC Treatment of Off-Gas	Potentially feasible
		Air Stripping with Advanced Oxidation Off-Gas Treatment	Not feasible, undemonstrated technology for off-gas treatment.
		Air Stripping with Off-Gas Treatment by Incineration	Not feasible due to large volume of off-gases.
		Advanced Oxidation (Ozone)	Potentially feasible
		Advanced Oxidation (Ozone/Peroxide)	Potentially feasible
		Advanced Oxidation (UV)	Potentially feasible
		Reverse Osmosis	Not feasible, undemonstrated for chlorinated organic compounds
		Ion Exchange	Not feasible, undemonstrated for chlorinated organic compounds

Process option that is screened out.

Table 10-1 (Cont'd.)

PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESSES FOR GROUNDWATER

General Response Action	Technology	Process Option	Preliminary Screening Comments
Treatment (Cont'd.)	Physical/Chemical (Cont'd.)	Precipitation	Not feasible, undemonstrated for chlorinated organic compounds
	Off-site	POTW	Potentially feasible
		RCRA Facility	Not feasible for large volumes of groundwater
	In-situ	Biotreatment Aeration Permeable Treatment Beds Chemical Oxidation	Not feasible due to large plume area and aquifer depth
Disposal	On-site Discharge of Treated Water	Reinjection	Potentially feasible
		Surface Drainage	Potentially feasible
	Off-site Discharge of Treated Water	POTW	Potentially feasible
		Municipal Water Supply	Potentially feasible
Containment	Vertical Barrier	Slurry Wall	Not feasible due to large plume area and aquifer depth
		Grout Curtain	Not feasible due to large plume area and aquifer depth
		Steel Sheet Piling	Not feasible due to large plume area and aquifer depth

Process option that is screened out.

Initial Screening - The groundwater use restriction is considered potentially feasible because it is implementable and protects the public, and is therefore retained for further evaluation in Section 11.0.

10.3 EXTRACTION

The extraction technology includes two process options or types of wells for extraction of groundwater. These wells are either extraction wells specifically located to extract contaminated groundwater, or existing municipal production wells.

10.3.1 Extraction Wells

Groundwater extraction wells are specifically designed to collect contaminated groundwater. These wells are designed to remove contaminated groundwater from specific vertical and horizontal plume areas in an aquifer. This allows the groundwater collection system to establish a zone of capture relative to the contaminant plume. Often a mathematical model is used to predict the response of an aquifer to pumping, and to assist in designing an extraction well system that creates the desired zone of capture, and can be used to estimate future states of contamination.

Initial Screening - Groundwater extraction well systems are considered potentially feasible because of the ability to capture groundwater at the Newmark depths in the aquifer where TCE and PCE are located, and are retained for further evaluation in Section 11.0.

10.3.2 Municipal Production Wells

Municipal production wells can be used to collect contaminated groundwater much like extraction wells. Well construction is an important consideration when evaluating an existing well for suitability as a collection well. These wells typically are designed to extract groundwater from aquifer zones that produce high quality drinking water and not for a zone of contaminant capture, which is desirable for remediation of an aquifer.

Initial Screening - Municipal production wells will be incorporated into the remedy because they can be used as extraction wells to extract water at the proper depths where TCE and PCE are located, and are retained.

10.4 SUBSURFACE DRAINS

Subsurface drains, sometimes referred to as French drains, consist of perforated pipe placed in a trench below the groundwater surface. The trench is lined with geotextile fabric to prevent plugging of the drain with fine soils and backfilled with gravel to allow groundwater to move freely into the perforated pipe. Contaminated groundwater is typically pumped from a sump connected to the sections of perforated pipe.

This process option is best suited for contaminants that are less dense than water. These contaminants normally do not migrate to deeper areas in the aquifer.

Initial Screening - This technology is generally used to collect small volumes of shallow groundwater and is not considered feasible for the large volumes of contaminated groundwater over twenty feet deep such as is the case at Newmark.

10.5 BIOLOGICAL TREATMENT

Biological treatment could consider two alternative process options, aerobic and anaerobic contaminant destruction. Both processes use microbial organisms to break down contaminants into less toxic compounds and are more effective at higher concentrations.

10.5.1 Aerobic Oxidation

Aerobic oxidation involves the biological removal of organic constituents from water by the action of microorganisms in the presence of free dissolved oxygen. Aerobic biological treatment results in the conversion of the organic compounds to intermediate organic by-products and finally to carbon dioxide and water. The result is the organic compounds are actually destroyed by the action of the bacterial organisms in water. However, an organic sludge is produced which must be disposed in an acceptable manner.

Aerobic biological treatment systems are not readily adaptable for removal of chlorinated VOC constituents from contaminated groundwater. A disadvantage is the process generates a waste stream. Also, if parameters change, such as microorganism concentrations, the process becomes unstable.

Initial Screening - This technology is undemonstrated for chlorinated organic compounds (e.g., TCE and PCE) and is not considered feasible for Newmark.

10.5.2 Anaerobic Digestion

Anaerobic digestion involves the biological removal of organic constituents from water or sludges by the action of microorganisms in the absence of oxygen. Anaerobic digestion results in the conversion of the organic compounds to intermediate organic acid and other by-products, and ultimately to carbon dioxide and methane. This process produces a sludge solid residual which requires disposal. Anaerobic digestion is similar to aerobic oxidation except that the reactions occur at a slower rate and less sludge is produced.

Anaerobic biological treatment systems are not readily adaptable for removal of chlorinated VOC constituents from contaminated groundwater. They have operational sensitivities which create a potentially unstable process, plus the generation of a solid waste stream.

Initial Screening - This technology is undemonstrated for chlorinated organic compounds and is not considered feasible for Newmark.

10.6 PHYSICAL/CHEMICAL TREATMENT (ON-SITE)

10.6.1 Aqueous Granular Activated Carbon

Granular activated carbon (GAC) is commonly used to remove VOC components from extracted groundwater, and is most effective for organic compounds with molecular weights from 100 to 5,000 grams per mole (g/mol). The molecular weights for TCE and PCE are 131 g/mol and 166 g/mol, respectively. Aqueous GAC involves the removal of VOCs from the contaminated groundwater by passage of the water through a packed bed of granular activated carbon to transfer the VOCs from the liquid phase to the solid phase by adsorption. The treated groundwater then passes out of the bottom of the GAC unit for additional treatment or subsequent discharge to its ultimate end use.

Spent activated carbon can be regenerated at either on-site or off-site facilities usually by heating with steam. The new or regenerated carbon may be returned to the bed for renewed contact with the contaminated groundwater and additional adsorption of the VOC compounds, where the cycle is repeated. Spent carbon can be disposed in a landfill or incinerated in a manner consistent with appropriate state and/or federal regulatory requirements.

Initial Screening - Aqueous granular activated carbon is considered potentially feasible and is retained for further consideration.

10.6.2 Air Stripping

Air stripping is a common method to remove contaminants from groundwater. The technology facilitates the contact of the contaminated water with air to transfer VOCs from the liquid to the gas phase. Typical air stripping systems employ the countercurrent contacting of air with water in a vertical packed tower. The tower is filled with a packing material that substantially increases the surface area of the contaminated water which comes in contact with the air. Water enters the top of the air stripping tower and air enters the bottom. Treated groundwater is collected in a sump at the bottom of the tower and discharged to further treatment, or the disposal or end use system.

To meet EPA VOC emission standards, site contaminants transferred from the liquid phase to the gas phase are generally passed through an emission control device to minimize release of contaminants to the atmosphere. The VOCs in the off-gas from the air stripping tower can normally be removed by passage through a vapor-phase activated carbon adsorption or advanced oxidation system, or by some type of gas stream incineration system.

Air Stripping with Vapor Phase GAC Treatment of Off-Gas - Off-gas treatment using GAC is commonly used to remove VOC components from vapors. The carbon is used and regenerated in the same manner described in Subsection 10.6.1 for aqueous GAC.

Initial Screening - Air stripping with GAC off-gas treatment is considered potentially feasible because it is demonstrated to be a feasible technology for removing TCE and PCE, and is retained for further evaluation.

Air Stripping with Advanced Oxidation Off-Gas Treatment - Off-gas treatment using advanced oxidation is considered an innovative technology which oxidizes organics in off-gas vapors through a reaction with ozone or another oxidizing material. This process, as applied to groundwater, is discussed further in Subsection 10.6.3 below.

Initial Screening - Air stripping with advanced oxidation off-gas treatment is an unproven technology for vapor phase treatment and is not considered feasible for Newmark.

Air Stripping with Off-Gas Treatment by Incineration - The contaminants that are transferred to the vapor phase from the air stripping process are thermally destroyed in an incinerator. This system requires a substantial amount of supplemental fuel to achieve the necessary air temperatures to accomplish complete combustion. Also, there is the potential for the production of toxic vapor by-products from combustion of chlorinated VOCs that would require an additional treatment system for removal.

Initial Screening - Air stripping with incineration off-gas treatment is not considered feasible for the off-gas flow rates expected at Newmark.

10.6.3 Chemical Oxidation

The chemical oxidation technology includes three processes that use oxidants to remove contaminants:

Advanced Oxidation (Ozone) - Ozone oxidation involves the removal of organic constituents in water by reaction with an oxidizing material, ozone, to decompose the contaminants. The oxidation process results in the actual destruction of the organic compounds to carbon dioxide and water plus other components in place of the transfer of the substance to the gaseous or solid phases. Ozone oxidation is most effective for removal of organic compounds in low concentration ranges.

Initial Screening - Advanced oxidation with ozone is considered potentially feasible because it is a recently demonstrated destructive technology for TCE and PCE, and is retained for further consideration.

Advanced Oxidation (Ozone/Peroxide) - This process is identical to the ozone oxidation process, with the exception that ozone and hydrogen peroxide are used as oxidizing agents. A system for the City of Southgate, similar to the system required for Newmark, has been performing satisfactorily, so as to suggest that advanced oxidation may be an appropriate process for treatment.

Initial Screening - Advanced oxidation using ozone and peroxide is considered the most feasible advanced oxidation process for TCE and PCE, and is retained for further consideration.

Advanced Oxidation (UV) - Ultraviolet (UV) oxidation involves the passage of contaminated groundwater through a reactor where it is irradiated by ultraviolet radiation for some interim time period. The retention time is determined by the type and concentration of organics in the groundwater, and the strength of the UV source lamp. The absorption of ultraviolet light by the contaminants results in the organic molecules being oxidized to carbon dioxide and water if sufficient dissolved oxygen is present. The treated water can then be discharged for further treatment, or to its end use.

The process is most effective for oxidizing higher molecular weight organic compounds that already incorporate oxygen in their respective chemical structures. The ultraviolet absorption process is relatively new and so there is no large body of data available regarding its performance at the present time. Also, the energy for the ultraviolet radiation that is supplied by electricity to the lamps is a significant power requirement.

Initial Screening - Advanced oxidation using UV is considered potentially feasible because it is a recently demonstrated destructive technology for TCE and PCE, and is retained for further consideration.

10.6.4 Reverse Osmosis

Reverse osmosis is primarily used for the removal of inorganic constituents from water, but may have some application for removal of organic compounds. Reverse osmosis involves pressurizing the water to cause it to selectively flow through a fine pore semipermeable membrane, which acts to block the passage of the ionic constituents and the larger organic molecules. Groundwater pre-treatment and post-treatment is required.

Initial Screening - This technology is undemonstrated for chlorinated organic compounds and is therefore not considered feasible for the Newmark site.

10.6.5 Ion Exchange

Ion exchange is primarily used for the removal of inorganic constituents from contaminated waters (demineralization). It has some application for removal of certain organic constituents in a manner similar to ion exchange demineralization. Ion exchange involves the replacement of ions from an organic resin with other ions from water. These ionic resins may also have the ability to either undergo ion exchange phenomena with organic functional groups, or else physically adsorb the VOC constituents from the contaminated groundwater.

Initial Screening - This technology is undemonstrated for chlorinated organic compounds and is not considered feasible for Newmark.

10.6.6 Precipitation

Precipitation separates the contaminants out of solution by altering the chemical equilibria to reduce the contaminants' solubility. This allows the contaminants to settle out of the groundwater in the solid phase. This technology is primarily used to precipitate metals from groundwater.

Initial Screening - This technology is undemonstrated for chlorinated organic compounds and is not considered feasible for Newmark.

10.7 OFF-SITE TREATMENT

This technology requires that contaminated groundwater be transported off-site for treatment. Process options for this technology include municipal water or sewer treatment plants (POTW), and RCRA facilities licensed to treat contaminated wastes.

10.7.1 Publicly Owned Treatment Works (POTW)

A local POTW is used to treat the extracted groundwater. Groundwater quality and flow rates must be determined to ensure that the POTW can effectively treat the additional loading without violating its discharge permit. Pre-treatment to reduce TCE and PCE concentrations may be required before treatment by the POTW.

Initial Screening - Using a POTW for treatment is considered potentially feasible because the POTW treatment system has the ability to treat TCE and PCE, and is retained for further evaluation.

10.7.2 Resource Conservation and Recovery Act (RCRA) Facility

Extracted groundwater is transferred to a RCRA facility, usually by truck, for treatment. Although the groundwater is not considered a RCRA hazardous waste, the water would be treated by a RCRA-permitted facility. This process option is limited to small volumes of contaminated waste that can be easily transported in drums for treatment.

Initial Screening - This technology is not feasible for large volumes of groundwater and is therefore not considered feasible for Newmark.

10.8 IN-SITU TREATMENT

In-situ treatment technologies incorporate some of the same underlying chemical or physical processes discussed earlier but the reactions are applied to groundwater in the aquifer. The process options are discussed separately and the initial screening summarizes all of them.

10.8.1 Biotreatment

Biological processes in-situ are simulated or enhanced by addition of bacteria, trace nutrients and other necessary metabolites, such as oxygen, into groundwater to degrade contaminants. The organic compounds are ultimately converted to carbon dioxide and water. Details of both aerobic and anaerobic biological treatment are discussed in Section 10.5.

10.8.2 Aeration

In this process option, sometimes referred to as air sparging, air is injected into the aquifer. The VOCs are transferred from the groundwater into the gas phase and the VOC-laden air is then removed by a soil venting (vacuum extraction) system. This process is particularly appropriate when a soil vapor extraction (SVE) system is required to remove contaminants from the vadose zone above the contaminated aquifer.

10.8.3 Permeable Treatment Beds

Downgradient trenches backfilled with activated carbon remove contaminants groundwater as it passes through the trench. This treatment is similar to carbon adsorption discussed in Subsection 10.6.1. Considering constructibility, it is only practical for shallow contaminated zones.

10.8.4 Chemical Oxidation

An oxidizer is injected into the aquifer to degrade contaminants. Chemical oxidation is discussed in Subsection 10.6.3.

Initial Screening - The in-situ treatment technology and its process options are not considered feasible due to the large plume area and aquifer depth at Newmark based on professional judgment, and will not be retained for further evaluation.

10.9 ON-SITE DISCHARGE OF TREATED WATER

After a treatment option on the surface, the resulting water must be discharged. The following discusses options on-site.

10.9.1 Reinjection

Treated groundwater is injected into the aquifer. This process can be used in conjunction with extraction wells to accelerate or enhance capture of a contaminant plume. Injection wells are placed downgradient of the plume. This creates a groundwater mound that can increase the groundwater gradient toward the extraction wells. Pretreatment by pH adjustment and disinfection may be required to prevent the injection wells from plugging due to chemical precipitation and biological growth.

Initial Screening - Using reinjection for discharge is considered potentially feasible because of the suitability for the range of depths at Newmark, and is retained for further evaluation.

10.9.2 Surface Drainage

This process option discharges extracted and treated groundwater to the ground surface for percolation, or into existing drainage systems. Discharge may occur either on-site or off-site depending on the location of existing facilities. Treatment prior to discharge is normally required to meet discharge standards of a National Pollutant Discharge Elimination System (NPDES) permit.

Initial Screening - Surface drainage discharge is considered potentially feasible because of the availability of surface drainage channels in the area, and is retained for further evaluation.

10.10 OFF-SITE DISCHARGE OF TREATED WATER

10.10.1 POTW

This process option disposes of the extracted groundwater into an existing municipal treatment facility. Pretreatment may be required if the POTW can process the hydraulic loading but not the contaminant loading, as discussed in Section 10.7. The local POTW's ability to process the additional hydraulic loading must be determined to evaluate this option.

Initial Screening - Using a POTW for discharge is considered potentially feasible and is retained for further evaluation.

10.10.2 Municipal Water Supply

Extracted groundwater is treated and discharged directly into a municipal water supply system. An evaluation is required to determine if the municipal water supply system can use the additional water.

Initial Screening - Using a municipal water supply for discharge is considered potentially feasible and is retained for further evaluation. This disposal method is currently being used at Newmark for the disposal of treated groundwater.

10.11 VERTICAL BARRIER

The containment technology uses processes that provide a vertical barrier to the movement of contaminated groundwater, as discussed in Section 9.4.

10.11.1 Slurry Wall

Areas of groundwater contamination are surrounded by a soil (or cement) bentonite slurry-filled trench. Slurry walls can be constructed to depths of up to 100 feet. Testing during construction and groundwater monitoring after construction are needed to ensure that the slurry wall barrier is providing the degree of impermeability required.

10.11.2 Grout Curtain

Grout curtains are functionally similar to slurry walls; they differ in the method of construction. Drilled holes are filled with grout to complete the barrier instead of a backfilled trench. The drilled holes must be overlapped to construct an impermeable barrier.

10.11.3 Steel Sheet Piling

This process option uses interconnecting steel sheets to provide an impermeable barrier. Sheet piling is commonly used in the construction industry to shore the walls of excavations while building subterranean structures.

Initial Screening - This technology and its process options are not considered feasible at Newmark due to the large plume area and aquifer depth and are not retained for further evaluation.

11.0 EVALUATION OF TECHNOLOGIES AND PROCESS OPTIONS

After initial screening, the technologies and process options which remained were evaluated on the basis of effectiveness, implementability, and relative cost. The evaluation emphasizes effectiveness and implementability; cost plays a limited role in this evaluation, and so relative costs are provided. Each evaluation criterion is discussed below.

Effectiveness - Each process option is compared to available process options within the same technology group. Each option is evaluated in terms of the potential effectiveness in meeting the remediation goals, the potential impacts to human health and the environment during the construction and implementation phase, and the reliability and the suitability of the process to remediate the site-specific contamination. This evaluation is qualitative, not quantitative, and is based on engineering experience.

Implementability - Implementability measures the technical and administrative feasibility of the process option. Technical feasibility is used to eliminate the process options that are clearly ineffective or unsuitable for the site.

Administrative feasibility refers to the ability to obtain permits for off-site actions and the availability of treatment, storage and disposal services. The availability of necessary equipment and technical personnel is also included.

Relative Cost - Because a limited emphasis is placed on cost at this phase of the evaluation as per EPA guidance, relative capital and operation and maintenance (O&M) costs are used to compare technologies and process options. Estimated costs are based on engineering judgment, and they are classified relative to other process options in the same technology type as high, medium or low.

Only the most feasible process options are retained for subsequent development of alternatives. Where possible, one process option will be retained for each technology. If process options for one technology provide advantages under different conditions, separate alternatives will be developed using each process option.

Table 11-1 summarizes the results for technologies and process options evaluated in this section.

11.1 MONITORING

The monitoring technology does not have process options other than monitoring.

Effectiveness - Monitoring by itself does not protect human health or the environment. It does not reduce toxicity or the volume of contaminants in the aquifer. Monitoring is effective in that it is useful for maintaining a database of contaminant concentrations and movement through the different phases of a project.

Implementability - It is typically not implementable on its own due to public and government regulations and is usually implemented as a component of an alternative.

Relative Cost - Monitoring has a comparatively low initial cost and low O&M costs.

Evaluation - The groundwater monitoring technology will be retained for development of alternatives as required by the NCP.

11.2 GROUNDWATER USE RESTRICTIONS

Only one process option, alternate water supply, is associated with the groundwater use restriction technology.

Table 11-1

EVALUATION OF PROCESS OPTIONS FOR GROUNDWATER

General Response Action	Technology	Process Option	Effectiveness	Implementability	Cost *
No Action	Monitoring	Monitoring	Useful to maintain a database. Does not reduce risk.	Not acceptable as sole action.	Low initial cost, low O&M.
~~Institutional Actions~~	~~Groundwater use restrictions~~	~~Alternate Water Supply~~	~~Good prevention of public health risk.~~	~~Relatively easy to obtain regulatory approval.~~	~~Potentially high initial cost, low O&M.~~
Collection/Treatment/Disposal					
Collection	Extraction	Extraction Wells	Very good for extracting groundwater.	Relatively easy to obtain regulatory approval.	High initial cost, low O&M.
		Municipal Production Wells	Good if wells are suitable.	Relatively easy to obtain regulatory approval.	High initial cost, low O&M.
Treatment	Physical/Chemical (On-Site)	Aqueous Granular Activated Carbon (GAC)	Effective VOC removal.	Relatively easy to obtain regulatory approval and to construct.	Medium initial cost, high O&M.
		Air Stripping with Vapor Phase GAC Treatment of Off-Gas	Effective VOC removal.	Relatively easy to obtain regulatory approval and to construct.	High initial cost, medium O&M.
		~~Advanced Oxidation (Ozone)~~	~~Effective VOC removal.~~	~~Relatively easy to obtain regulatory approval and to construct.~~	~~High initial cost, high O&M.~~
		Advanced Oxidation (Ozone/Peroxide)	Effective VOC removal	Relatively easy to obtain regulatory approval and to construct.	High initial cost, high O&M.
		~~Advanced Oxidation (UV)~~	~~Low for VOC removal when used by itself.~~	~~Relatively easy to obtain regulatory approval and to construct.~~	~~High initial cost, high O&M.~~
	Off-site	~~POTW~~	~~Good if capacity is available.~~	~~Regulatory approval depends on available capacity.~~	~~High initial cost, high O&M.~~
Disposal	On-site Discharge of Treated Water	Reinjection	Very good disposal method.	Sometimes difficult to obtain regulatory approval.	High initial cost, low O&M.
		Surface Drainage	Good to very good.	Sometimes difficult to obtain regulatory approval.	Low initial cost, very low O&M.

Table 11-1 (Cont'd.)

EVALUATION OF PROCESS OPTIONS FOR GROUNDWATER

General Response Action	Technology	Process Option	Effectiveness	Implementability	Cost *
Disposal (Cont'd.)	Off-site Discharge of Treated Water	POTW	Good if capacity is available.	Regulatory approval depends on available capacity.	High initial cost, high O&M.
		Municipal Water Supply	Good if capacity is available.	Relatively easy to obtain regulatory approval.	Low initial cost, high O&M.

Effectiveness - An alternate water supply designation is effective in preventing public ingestion of contaminated water; however, this technology does not reduce toxicity, mobility or volume of groundwater contamination.

Implementability - Groundwater use restrictions can only be implemented if there is an adequate alternate water supply available or that can be made available. Installation of additional municipal wells in uncontaminated areas may be required. The technology and equipment needed for well installation is readily available. Regulatory approval is relatively easy to obtain.

Relative Cost - There is no cost associated with restricting groundwater use, unless the required restriction installation of new municipal water production wells. In that case, there would be a high initial cost and low O&M costs.

Evaluation - Groundwater use restrictions will not be retained for development of alternatives because many production wells have already been contaminated. Replacement of these wells in uncontaminated areas would require a significant amount of piping to reach the treatment systems, which is not feasible.

11.3 EXTRACTION

The extraction technology is the first component in the collection/treatment/disposal general response action. Two process options, extraction wells and municipal production wells, are available within this technology. To be effective, extraction depends on a number of factors, such as proper site location, screen depths, and possible pumping rates. To accomplish determining the various quantities, site groundwater modeling is typically undertaken.

11.3.1 Extraction Wells

Effectiveness - Wells, an established process, are effective in extracting contaminated groundwater over the plume area at the required depth. Extraction of contaminated groundwater is very effective in reducing the further spread (and ultimately reducing the extent), and volume of contaminated groundwater which would meet the Remedial Action Objectives to restore water quality of the aquifer over the long-term. They are also effective in the short-term because workers and the public are not exposed to contaminated groundwater during construction.

Implementability - Because of their common use, it is relatively easy to implement the extraction well process option. Extraction well technology and equipment are available for virtually any aquifer condition. Regulatory approval is generally easy to obtain.

Relative Cost - Extraction wells have a relatively high capital cost and a low O&M cost.

Evaluation - Extraction wells will be retained for development of alternatives because they are effective in meeting the Remedial Action Objective to restore the water quality of the aquifer.

11.3.2 Municipal Production Wells

Effectiveness - This process is effective in meeting the remedial action objective of preventing ingestion of contaminated groundwater. However, municipal production wells may not be as effective as extraction wells in restoring the quality of the aquifer because existing wells are not designed (in location, screen depth, and operation) to optimally achieve restoration. If new production wells are installed in conjunction with a treatment system, it would be advantageous to design these wells with the characteristics of an extraction well to maximize restoration of the aquifer.

Implementability - Using existing production wells is easy to implement. A treatment process will be required to meet drinking water standards. Municipal production wells have the same implementability characteristics as extraction wells.

Relative Cost - If existing wells are used, the initial capital cost is very low. Installing new production wells has a relatively high capital cost and a low O&M cost.

Evaluation - Municipal production wells will be retained for incorporation into the remedy, and are discussed further in Section 13.0.

11.4 PHYSICAL/CHEMICAL TREATMENT (ON-SITE)

Several process options are evaluated for the physical/chemical technology to meet the treatment general response action. The number of treatment options will be reduced to retain the most feasible processes for development of alternatives. As alternatives are developed through the FS process, treatment technologies screened out may need to be revisited as more information is obtained.

11.4.1 Aqueous GAC

Effectiveness - Aqueous GAC is very effective to remove VOCs because it is able to obtain higher removal efficiencies than air stripping for the higher molecular weight constituents. It does not result in the generation of a liquid or gaseous phase effluent stream that requires further treatment before final discharge, and requires no additional fans or pumps for operation. The GAC process has the disadvantage of generating spent carbon contaminated with the collected VOCs. These materials require disposal by landfilling or incineration, and may be classified as hazardous waste. If the carbon is regenerated to facilitate reuse, this regeneration step must be carried out by a relatively complex process either on-site or at an off-site location.

Implementability - Aqueous GAC is a commercially proven technology for VOC removal from contaminated groundwater with a number of successful installations already in place. Because it is a familiar technology, GAC systems are relatively easy to implement with respect to permitting and construction. The GAC system is more complex in its operation than a similar air stripping system because of the periodic need for bed backwashing and possible regeneration.

Relative Cost - The aqueous GAC system may have a higher initial cost than an air stripping unit of comparable treatment capacity if air stripper off-gas treatment is not required. Carbon must be periodically replaced, using either new or regenerated carbon. The GAC system has a higher resulting operating cost than air stripping.

Evaluation - The aqueous GAC process option will be retained for development of alternatives.

11.4.2 Air Stripping with Vapor Phase GAC Treatment of Off-Gas

Effectiveness - Air stripping with GAC treatment of off-gas is very effective in that it is able to achieve a very high removal efficiency for lighter, more volatile constituents. Air stripping provides predictable performance for removal of VOCs at both high and low concentrations. Air stripping has the disadvantage of requiring electrical energy for the movement of both the air and water streams through the stripping tower. Periodic cleaning with sodium hypochlorite or an acid solution may be required to control scale formation and biological growth on the packing material surfaces when mineral-laden waters are being treated. Air stripping with GAC treatment of off-gas meet the remedial action objectives for both protection of human health and the environment in that it reduces the volume of contaminants in the effluent groundwater.

Implementability - Air stripping with GAC treatment of off-gas is a proven technology with a number of successful installations already in place. This system is easily implemented with respect to permitting and construction, and provides simple, reliable operation over extended periods of time.

Relative Cost - Overall, air stripping with GAC treatment of off-gas has a relatively high capital cost and medium O&M costs.

Evaluation - Air stripping with GAC treatment of off-gas will be retained for development of alternatives due to its established effectiveness for large volumes of groundwater.

11.4.3 Advanced Oxidation (Ozone)

Effectiveness - The ozone oxidation process is effective, as it is able to achieve high degrees of VOC destruction and is suitable for low inlet concentration streams. However, it is most often used to reduce general organic contamination, and treatment of specific organic contaminants is only now being studied extensively. A potential disadvantage is that toxic by-products may be formed that would require additional removal equipment, increasing chemical oxidation process costs.

Implementability - Because it is a relatively simple process with relatively few pieces of equipment required, it is easily implemented with respect to construction. Approval is usually attained relatively easily.

Relative Cost - There are relatively high costs associated with the ozone oxidation process. The process has a high energy requirement for ozone generation and a high ozone addition requirement, giving it a high operating cost. The ozone can require a long contact time in order to carry the reactions through to completion. This can result in a physically large process unit and an accompanying large capital cost.

Evaluation - The advanced oxidation process using ozone will not be retained for development of alternatives because ozone alone is not able to completely oxidize TCE and PCE.

11.4.4 Advanced Oxidation (Ozone/Peroxide)

The criteria evaluation for this process is similar to that for the ozone oxidation process in the previous evaluation, with the exception that ozone and hydrogen peroxide are used as oxidizing agents.

Evaluation - The advanced oxidation process using ozone and peroxide will be retained for development of alternatives because this process is considered to be the most effective advanced oxidation process for TCE and PCE.

11.4.5 Advanced Oxidation (UV)

Effectiveness - Ultraviolet photolysis is ineffective by itself to reduce VOC levels to the levels required to meet ARARs for most contaminated groundwater conditions. The process is relatively simple, but may require significant retention time by itself. It can also result in the generation of certain potentially harmful intermediate by-products.

One method to increase effectiveness of VOC destruction by ultraviolet oxidation is to add an oxidizing agent. Ozone, hydrogen peroxide, or both chemicals are initially added to the contaminated groundwater to begin the process of oxidation. The oxidant-rich groundwater is then passed through the photolysis reactor where it is contacted with ultraviolet light, which provides the energy to substantially increase the otherwise relatively slow reaction rates.

Implementability - UV oxidation has the same implementability characteristics as ozone and ozone/peroxide destruction.

Relative Cost - The process has a relatively high initial cost and high operating costs because of its associated electric power requirements.

Evaluation - The advanced oxidation process using UV will not be retained for development of alternatives because RI site information indicates that UV would not be required in the oxidation process with ozone and peroxide.

11.5 OFF-SITE TREATMENT

Off-site treatment can be accomplished by discharging extracted groundwater into the local sanitary sewer system for treatment at a POTW. The discharge to a RCRA facility as a process option was eliminated in the initial screening.

11.5.1 POTW

Effectiveness - This process is effective if the local sanitary sewer treatment facility can manage the additional volume of water and VOC loading. If capacity exists, this process option meets both Remedial Action Objectives by reducing the volume of contaminants and prevents public ingestion of VOCs.

Implementability - Using a POTW for off-site treatment cannot be implemented because treatment capacity is unavailable. The capacity of the local POTW is currently 30 million gallons per day (mgd). The expected load capacity from Newmark would require an additional capacity of approximately 10 mgd or 33% minimum, which is not possible to accommodate at this time.

Relative Cost - Using a POTW would have a relatively high initial cost of approximately $4 to $5 per gallon of wastewater capacity if the sewer and treatment systems require additional capacity. Operation and Maintenance costs are very high because of flow rate charges by the POTW.

Evaluation - The POTW treatment process option will not be retained for development of alternatives, because the necessary disposal capacity is not available and the associated costs are high.

11.6 ON-SITE DISCHARGE OF TREATED WATER

On-site discharge includes two process options, injection wells and surface drainage, as the possible disposal component of the collection/treatment/disposal general response action.

11.6.1 Reinjection

Effectiveness - Injection wells are effective because the locations and depths of reinjection can be selected to assist in management of the plume. Pretreatment may be required prior to injection to inhibit scaling and biological growth in the wells. The groundwater resource is also returned to the aquifer for future use. They are particularly feasible in highly permeable aquifers such as Newmark. They must be carefully designed and operated to ensure that they do not become plugged during operation.

Implementability - Disposal of treated groundwater into an aquifer may require substantial effort to obtain approval from appropriate agencies. The treatment must ensure that drinking water standards are met before injection. Injection wells have been demonstrated in many locations and equipment is available for construction. Existing models can be used to site and design the wells and their operation.

Relative Cost - The initial cost is relatively high compared to surface or municipal water supply discharge if these options are feasible. Operation and Maintenance costs are low if properly maintained. Given the ability to assist with management of the plume, benefits may accrue due to a shorter remedial duration.

Evaluation - Reinjection will be retained for development of alternatives.

11.6.2 Surface Drainage

Effectiveness - Surface drainage is a quick solution for discharging treated groundwater if drainage facilities capable of accepting treated volumes of groundwater are available. These capabilities will be evaluated in Section 13.0.

Implementability - Regulatory approval is sometimes difficult to obtain for surface drainage disposal. An NPDES permit is required that can require many months to obtain.

Relative Cost - Overall cost is relatively low if facilities are available. Operation and Maintenance costs associated with this disposal process to maintain the drainage channel(s) are minor.

Evaluation - The surface drainage disposal process option will be retained for development of alternatives. Surface discharge will be combined with other disposal processes to provide flexibility in operation.

11.7 OFF-SITE DISCHARGE OF TREATED WATER

11.7.1 POTW

The POTW disposal option is similar to the POTW treatment option discussed in Subsection 11.5.1, except that the groundwater is treated prior to discharge to the POTW to reduce the contaminant loading.

Evaluation - The POTW disposal process option will not be retained for development of alternatives because the necessary disposal capacity is not available and the associated costs are high.

11.7.2 Municipal Water Supply

This disposal process option is used in conjunction with municipal wells or extraction wells and either well head treatment or an existing municipal treatment facility. Capacity must be available in the potable water system or improvements made to implement this option. Refer to Section 11.3 for the evaluation of this process option with respect to off-site discharge.

Evaluation - The municipal water supply disposal process option will be retained for development of alternatives.